

Answer to comments from Referee 2

On “Sustainability of water uses in managed hydrosystems: human- and climate-induced changes for the mid-21st century” by Fabre et al.

▪ Referee comment

The paper aims at characterizing the sustainability of water management rules for two Mediterranean basins under the context of global change. This manuscript is well written and well organized and I have only few recommendations before publication.

The results presented here, which focus on the future, complement previous published works on the general modelling framework and its former application under past conditions (Fabre et al., 2015; Grouillet et al., 2015).

Authors’ response

We would like to thank the referee for reviewing the submission and for his interest in the topic, as well as for his attentive review of our submitted paper.

▪ Referee comment

P 9252: 18 projections are not enough to consider that they form a “wide” range of possible climate scenarios”.

Authors’ response

We replaced “a wide range of possible climate scenarios” with “a range of possible climate scenarios” (p. 4 line 104 and p.9 line 281 of the attached file).

▪ Referee comment

P 9254: the Florensac transfer is not displayed on the map (Fig. 1).

Authors’ response

The Florensac transfer is indicated on the map in Figure 1 by the arrow at the South of the Herault basin pointing towards “to coastal towns”. The indication “Florensac transfer (to coastal towns)” was added for more clarity.

▪ Referee comment

P 9255: “by withdrawals inside” => “by withdrawals inside and outside”

Authors' response

In fact, the intended meaning is “by withdrawals inside the sub-basin” and no “inside and outside” the sub-basin. However the text refers to water uses (indeed outside or inside the basin) supplied by withdrawals inside the basin. A clarification was added in the sentence (page 6 line 175 of the attached file):

“In the Herault basin the surface flow at the outlet of each sub-basin was considered to represent water availability for all water uses (*inside or outside the basin*) supplied by withdrawals inside the sub-basin.”

▪ **Referee comment**

P 9257: it is not clear on which time step the analyses (in particular the comparisons to the thresholds derived from monthly discharges) were carried out (daily, 10-day, monthly).

Authors' response

The analyses were carried out at a 10-day time step for water demand satisfaction, including the environmental flow Q_{MIN} . “At a 10-day time step” was added at page 9257 line 5 (page 7 line 216 of the attached file).

Influenced streamflow simulated at a 10-day time step was then averaged at a monthly time scale and monthly influenced streamflow was compared to Q_{OBJ} at a monthly time step (as is explained in section 332, page 11 line 368 of the attached file).

▪ **Referee comment**

P 9259: ET0 is given by Penman-Monteith formula under current conditions for the Herault basin. How are ET0 values obtained under climate projections since other climate data than temperature are required?

Authors' response

The following two sentences were added in section 3.2.1 to clarify this point (see page 9 line 297 of the attached file).

“ET0 was then calculated in each climate change scenario, using the FAO Penman-Monteith formula in the Herault basin and the Hargreaves empirical equation in the Ebro basin. The climate data other than temperature that are required in the Penman-Monteith formula (wind speed, net radiation, e.g.) were considered unchanged in the climate scenarios: the values from SAFRAN over 1976-2005 were used in all climate scenarios for 2036-2065.”

▪ **Referee comment**

P 9261: how are changes distributed within the two basins? In section 4.1.2, one can find that the increase in irrigated areas (65% and 90%) varies from one sub-basin to another. This is not really consistent with Table 2 (80%).

Authors' response

To clarify this point the sentence in section 3.2.2

“The changes applied to the main drivers of water demand between the current and the trend water use scenarios are presented in Table 2.”

Was completed with

“The changes applied to the main drivers of water demand between the current and the trend water use scenarios are presented in Table 2 *at the river basin scale. These changes were distributed spatially between the demand nodes.*” (page 10 line 311 of the attached file)

▪ **Referee comment**

P 9261: do Q_{min} and Q_{obj} remain unchanged under climate change scenarios?

Authors' response

Yes Q_{MIN} and Q_{OBJ} remain unchanged under climate change scenarios, since they are considered to be a fixed water management criteria which local stakeholders have not, to date, planned to adapt to future changes in streamflow. The following sentence was added (p.10 line 339 of the attached file):

“Water demand for human water uses was calculated for current water uses and for future water uses, both under past and future climate conditions for irrigation water demand. The thresholds Q_{MIN} and Q_{OBJ} for environmental water demand were kept unchanged in all scenarios.”

▪ **Referee comment**

P 9264: pojected = > projected

Authors' response

Agreed. This has been corrected.

▪ **Referee comment**

P 9264: could you identify the upstream / downstream sections in the graphs?

Authors' response

The outlet of the Herault and the Ebro basins were identified in the graphs for more clarity and easier identification of the upstream/downstream sections.

▪ **Referee comment**

P 9264: is there any explanation to the decrease in AWD for some sub basins of the Ebro River? (decrease in ET0?)

Authors' response

In some climate change scenario spring precipitation is projected to increase. Associated with a low or negligible decrease in summer precipitation and in the scenarios with a lower temperature (hence ET0) increase, this could explain the decrease in AWD for some sub basins of the Ebro River.

▪ **Referee comment**

P 9265: could you add and comment the changes in total stored water volume in the reservoirs on the graphs?

Authors' response

Unfortunately we are not sure we have understood the question correctly. Does the Referee wish for us to add a figure with changes in the stored volumes in the reservoirs in both basins?

▪ **Referee comment**

P 9268: it is not clear for me on which time step the analyses were carried out regarding the environmental flows.

Authors' response

The analyses regarding environmental flows Q_{OBJ} presented on page 9268 were carried out at a monthly time step. This is indicated in the methods sections (p.11 line 368 of the attached file). The sentence was slightly modified for more clarity: "Finally, *simulated* influenced monthly streamflow was compared for each combination of scenarios to the monthly environmental flows Q_{OBJ} described in section 3.1.1 and the frequency of non-compliance with these monthly environmental flows was calculated".

Also in the results section (p.9268 of the discussion paper, page 15 of the attached file) the following sentence was modified:

From “ Figure 7 shows that monthly environmental flows Q_{OBJ} are reached more than eight years out of ten in all sub-basins of the Herault and the Ebro basins (...)”

To “Figure 7 shows the results of the comparison of simulated influenced streamflow with environmental flows Q_{OBJ} at a monthly time step. Monthly environmental flows Q_{OBJ} are reached more than eight years out of ten in all sub-basins of the Herault and the Ebro basins (...)”.

▪ **Referee comment**

Table 1: Martin et al. is missing

Table 2: “et” should be deleted

Table 3: 2050 => 2050s

Authors’ response

Agreed. Modifications were made accordingly.

▪ **Referee comment**

Figure 2: only “Reservoir level” is on the graph. I suggest adding “Transfer”. At which time step, return flows are computed? What does dashed arrow mean? One arrow is missing: we do not know where “return flows” flow.

Authors’ response

Return flows and consumptive use are computed at a 10-day time step. This was added in Figure 2. Also, an arrow showing return flows contribute to influenced streamflow was added.

Finally, the dashed arrow was meant to show that the modeling chain was applied from upstream to downstream until the outlet. However since it seemed unclear we changed it to a full arrow.

▪ **Referee comment**

Figure 5: it is difficult to identify points related to “2000s water uses Reference climate”. I suspect that polygons and curves overlap.

Authors’ response

Agreed. The figure was slightly modified for more clarity. In the original figure in some cases in the “2000s water uses Reference climate” situation there was no deficit, a red dot in the middle of the radar charts was added to show this. In the cases where “2000s water uses Reference climate” and “2050s water uses Reference climate” overlap, we tried to make the dotted line more visible.

▪ **Referee comment**

Figure 7: There are more gauging stations in the two basins than the number of sites displayed. Why do the authors consider this selection of basins?

Authors' response

The following sentence was added in section 3.1.1. to clarify this point (p. 7 line 228 of the attached file):
“ Q_{OBJ} values were considered in the Herault basin at the outlet of each of the defined sub-basins where the local water agency had defined an objective flow (i.e. at the outlets of the Lodeve, Saint Laurent, Gignac and Agde areas). In the Ebro basin they were considered at the outlet of the defined sub-basins not corresponding to the direct outlet of a dam (for which reserved environmental flows are integrated in the dam management rules).”